2024 Y6 H2 Chemistry Preliminary Exams Paper 1 – Suggested Solutions

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Answer	A	B	B	C	C	D	B	D	C	A	B	A	D	A	A

Question	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Answer	D	B	C	A	D	B	D	B	C	C	D	D	B	C	A

MCQ worked solutions

Q1 (Ans: A)

At r.t.p, number of moles of molecules in 1 cm^3 of CH_4 gas = $\frac{1}{24000}$ mol

number of molecules in 1 cm^3 of CH_4 gas = $\frac{6.02 \times 10^{23}}{24000}$

Q2 (Ans: B)

$C_xH_y(g) + (x+\frac{y}{4})O_2(g) \rightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

Volume of CO_2 produced = 100 − 40 = 60 cm^3
Volume of unreacted O_2 = 40 cm^3
Volume of O_2 reacted = 130 – 40 = 90 cm^3
Hence, x = $\frac{60}{20}$ = 3.
$(x+\frac{y}{4}) = (3+\frac{y}{4}) = \frac{90}{20}$
y = 6

Thus, formula of the hydrocarbon is C_3H_6.

Q3 (Ans: B)

Option A is incorrect as $^{18}O^{2-}$ and $^{19}F^{-}$ each has 10 electrons and 10 neutrons.
Option B is correct as both $^{18}O^{2-}$ and $^{19}F^{-}$ have 10 neutrons each.
Option C is incorrect as both ions have outer electronic configuration of $2s^2\ 2p^6$.
Option D is incorrect as nucleons refer to protons and neutrons. Hence $^{18}O^{2-}$ has 18 nucleons and $^{19}F^{-}$ has 19 nucleons.

Q4 (Ans: C)

After the beta decay, the mass number remains the same at 234 and the resulting species has 90 + 1 = 91 protons, which is protactinium (Pa).

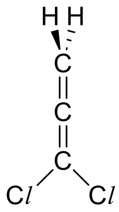
Q5 (Ans: C)

Option A is incorrect as boiling involves overcoming intermolecular forces (hydrogen bonding) and does not involve the breaking of covalent bonds. Furthermore, the F−H bond is stronger than the O−H bond.
Option B is incorrect as both H_2O and HF are isoelectronic (same number of electrons).
Option C is correct as, on average, each H_2O can form 2 hydrogen bonds per molecule whereas each HF only forms 1 hydrogen bond per molecule.
Option D is incorrect as the statement is not a major reason for the higher boiling point of H_2O since hydrogen bonding is the predominant intermolecular force of attraction.

Q6 (Ans: D)

Option A is incorrect as ice is less dense than water due to its open structure, preventing the molecules from getting too close to one another. This also causes the same mass of H_2O to occupy a larger volume.
Option B is incorrect as covalent O−H bonds are stronger than hydrogen bonds.
Option C is incorrect as each O atom forms 2 hydrogen bonds, hence 4 electrons (2 electron pairs) are involved.
Option D is correct as each H_2O molecule is tetrahedrally bonded to four H atoms via covalent and hydrogen bonds.

Q7 (Ans: B)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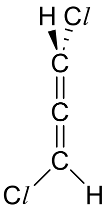
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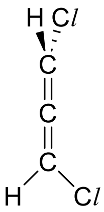
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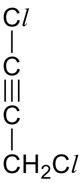
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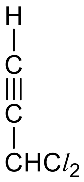

(5)

Option 1 is correct to adhere to the given molecular formula and non-cyclic structure.
Option 2 is incorrect as isomers 2 and 3 are optically active as they lack an internal plane of symmetry. However, both do not contain any chiral C atom.
Option 3 is correct as there is a total of five non-cyclic isomers, including stereoisomers.

Q8 (Ans: D)

$pV = nRT$

Option A is incorrect as $p \propto T$, in K, at constant V. Since units of T on x-axis is °C, when $p = 0$, $T = -273$ °C. The graph should not pass through the origin.
Option B is incorrect as $pV = nRT$ = constant at constant T. Hence, the graph should be a vertical line.
Option C is incorrect as $V \propto 1/p$ at constant T. Hence, the graph should resemble a $y = \frac{1}{x}$ hyperbolic graph, with asymptotes along x and y axes.
Option D is correct as $p/T = nR/V$ = constant at constant V. Hence, the graph should be a horizontal line.

Q9 (Ans: C)

Atomic radius decreases across a period from sodium to chlorine.
Electronegativity increases across the period from sodium to chlorine.
The first ionisation energy of elements generally increase across a period from sodium to chlorine.

Q10 (Ans: A)

Only MgO dissolves sparingly in water to form $Mg(OH)_2$. SiO_2 and Al_2O_3 are insoluble while Na_2O and SO_2 dissolves completely in water. Hence, options A and B are possible answers.

$MgCl_2$ solution has a pH of 6.5, which is higher than that of Al_2Cl_3 solution (pH of 3). Hence, option A is correct. NaCl has a pH of 7, and hence option B is incorrect.

Q11 (Ans: B)

Option A is incorrect as the boiling point of X_2 increases down the group due to stronger instantaneous dipole-induced dipole interactions between the molecules. Hence, the volatility decreases down the group.
Option B is correct as the bond length of X_2 increases down the group due to increase in the size of the atom down the group.
Option C is incorrect as the bond energy of X_2 decreases down the group as the electron cloud of the atoms get more diffused down the group and the effectiveness of orbital overlap decreases down the group.
Option D is incorrect as the oxidizing power of X_2 decreases down the group since the tendency of X_2 to gain electrons decreases down the group.

Q12 (Ans: A)

$$\begin{tikzcd}
2NO(g) + O_2(g) \arrow[r, "\Delta H"] & N_2O_4(g) \\
N_2(g) + 2O_2(g) \arrow[u, "2\times(+91)"] \arrow[r, "2\times(+34)"] & 2NO_2(g) \arrow[u, "-58"']
\end{tikzcd}$$

$\Delta H = -2\times(+91) + 2\times(+34) + (-58) = -172$ kJ mol^{-1}

Q13 (Ans: D)

	Reaction	Sign of ΔH
ΔH_1	enthalpy change of reaction between sodium and hydrochloric acid $2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) \quad \Delta H_r^{\ominus} < 0$ $OH^-(aq) + H^+(aq) \longrightarrow H_2O(l) \quad \Delta H_r^{\ominus} < 0$	negative
ΔH_2	enthalpy change of combustion of sodium	negative
ΔH_3	enthalpy change of reaction between sodium oxide and hydrochloric acid	Cannot be determined from the question
ΔH_4	enthalpy change of combustion of hydrogen	negative

Option A is incorrect as $\Delta H_1 + \Delta H_2$ is always negative.

Option B is incorrect as $\Delta H_3 + \Delta H_4$ is not always positive since ΔH_4 is negative.

Option C is incorrect, by Hess' Law, $\Delta H_3 - \Delta H_4 - \Delta H_1 = -\Delta H_2$, and $-\Delta H_2$ is positive.
Option D is correct, by Hess' Law, $\Delta H_2 + \Delta H_3 - \Delta H_1 = \Delta H_4$ and ΔH_4 is negative.

Q14 (Ans: A)

Option A is correct. When [CH_3CHO] = c, the active sites of the enzymes become saturated with CH_3CHO. Further increase in [CH_3CHO] will not have any effect on the reaction rate.
Option B is incorrect. When [CH_3CHO] = c, the order of reaction with respect to [CH_3CHO] is zero.
Option C is incorrect. When [CH_3CHO] = c, the reaction rate remains constant as long as the active sites of the enzymes remain saturated with CH_3CHO.
Option D is incorrect. When [CH_3CHO] = c, the reaction rate remains constant but non-zero.

Q15 (Ans: A)

For $X(g) \rightleftharpoons Y(g)$, $K_c = \frac{[Y]}{[X]}$ and $K_p = \frac{p_Y}{p_X}$

Statement 1 is correct. Given that X and Y behave as ideal gases, $p_X V = n_X RT$ and hence $p_X = [X]RT$. Thus, $K_p = \frac{p_Y}{p_X} = \frac{[Y]RT}{[X]RT} = \frac{[Y]}{[X]} = K_c$.

Statement 2 is correct. Under the same conditions, K_p is constant regardless if the equilibrium was achieved from 100% of X(g) or 100% of Y(g). Thus, $\frac{p_Y}{p_X} = K_p$ remains constant.

Statement 3 is correct. Adding more X(g) increases the concentration of X(g) and the position of equilibrium of $X(g) \rightleftharpoons Y(g)$ shifts to the right to partially offset this increase. However, at the same temperature, K_p is constant and hence the partial pressures of both gases must increase so that $K_p = \frac{p_Y}{p_X}$ = constant.

Q16 (Ans: D)

$NH_3(aq) + HNO_3(aq) \longrightarrow NH_4^+(aq) + NO_3^-(aq)$

When HNO_3 was titrated against NH_3, NH_3 is added from the burette to HNO_3 in the conical flask.

vol. of NH_3 added / cm^3	remarks
10	The conical flask contains unreacted HNO_3 and the product, NH_4^+, which does not act as a buffer.
20	All the HNO_3 is completely neutralised and the conical flask contains the product, NH_4^+, which does not act as a buffer.
30	20 cm^3 of NH_3 is used for neutralisation and the remaining 10 cm^3 is in excess. The conical flask contains excess NH_3 and the product, NH_4^+, in the ratio 1 : 2 and hence can act as a buffer but does not have maximum buffering capacity
40	20 cm^3 of NH_3 is used for neutralisation and the remaining 20 cm^3 is in excess. The conical flask contains excess NH_3 and the product, NH_4^+, in the ratio 1 : 1 and hence can act as a buffer with maximum buffering capacity.

Q17 (Ans: B)

$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

K_b for $CH_3COO^- = \frac{K_w}{K_a} = \frac{10^{-13.3}}{1.63 \times 10^{-5}} = 3.0748 \times 10^{-9}$ mol dm^{-3}

At equilibrium, $[OH^-] = [CH_3COOH]$

$[CH_3COO^-]_{eqm} \approx [CH_3COO^-]_{initial} = 1$ mol dm^{-3}

since CH_3COO^- is a weak acid with a small K_b.

$[OH^-] = \sqrt{K_b \times [CH_3COO^-]} = \sqrt{3.0748 \times 10^{-9} \times 1} = 5.5451 \times 10^{-5}$ mol dm^{-3}

$pH = pK_w - pOH = 13.3 - [-\lg(5.5451 \times 10^{-5})] = 9.04$

Q18 (Ans: C)

Option A is incorrect as there is no common ion between $NaCl$ and $MgCO_3$.
Option B is incorrect as the addition of $H_2O(l)$ decreases the concentration of dissolved $MgCO_3$, causing the solution to be no longer saturated and no precipitate will form.
Option C is correct as $K_2CO_3(s)$ will dissolve in water to form $CO_3^{2-}(aq)$, increasing the $[CO_3^{2-}]$ and causing ionic product of $MgCO_3 = [Mg^{2+}][CO_3^{2-}]$ to exceed K_{sp} of $MgCO_3$, causing the formation of $MgCO_3$ precipitate.
Option D is incorrect as $HCl(aq)$ will react with $MgCO_3$ in an acid-base reaction to decrease the concentration of CO_3^{2-} and the solution will no longer be saturated and no precipitate will form.

Q19 (Ans: A)

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$ $E^\ominus = +1.33\ V$ ... (1)
$Fe^{3+}(aq) + 2e^- \rightleftharpoons Fe^{2+}(aq)$ $E^\ominus = +0.77\ V$ ... (2)
Reduction at G (cathode): $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$
Oxidation at F (anode): $Fe^{3+}(aq) \longrightarrow Fe^{2+}(aq) + e^-$
Overall: $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 3\ Fe^{2+}(s) \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 3\ Fe^{3+}(aq)$

$E^\ominus_{cell} = E^\ominus_{cathode} - E^\ominus_{anode} = +1.33 - (+0.77) = +0.56\ V$
Electrons are produced at F (anode) and flows to G (cathode).

Q20 (Ans: D)

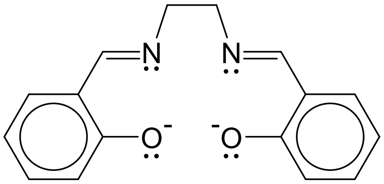
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$ $+2.01\ V$
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$ $+1.23\ V$
At the anode, water is preferentially oxidised to oxygen. Hence, option B is incorrect.
$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$
Oxygen evolved reacts with the aluminium and an inert layer of Al_2O_3 is formed.
Hence, option D is correct.
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$ $-0.83\ V$
$2H^+ + 2e^- \rightleftharpoons H_2$ $+0.00\ V$
At the cathode, hydrogen ion is preferentially reduced to hydrogen gas and there is no change in mass of the cathode. Hence, options A and C are incorrect.

Q21 (Ans: B)

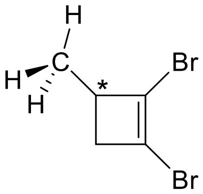
Option A is incorrect as copper is a transition metal, and has a much higher density than potassium.
Option B is correct as potassium is not a transition metal and does not form coloured compounds while copper can form copper(I) compounds which have a fully filled 3d subshell, preventing the 3d electrons from undergoing d-d transition, thus appearing white in colour.
Option C is incorrect as potassium does not form stable compounds with oxidation state of +2 (no variable oxidation states).
Option D is incorrect as potassium only uses electrons from the 4s subshell for metallic bonding, while copper can use electrons from both 4s and 3d subshells for metallic bonding.

Q22 (Ans: D)

Statement 1 is incorrect as the central Mn atom does not have six bond pairs of electrons.
Statement 2 is correct as Mn-salen metal complex has no net charge while the two nitrogen atoms in the tetradentate ligand below are uncharged and the two oxygen atoms are singly charged, together with the singly charged monodentate Cl^{-} ligand, Mn has an oxidation number of +3.
Statement 3 is correct as the monodentate ligand is Cl^{-} while the tetradentate ligand is as shown below.



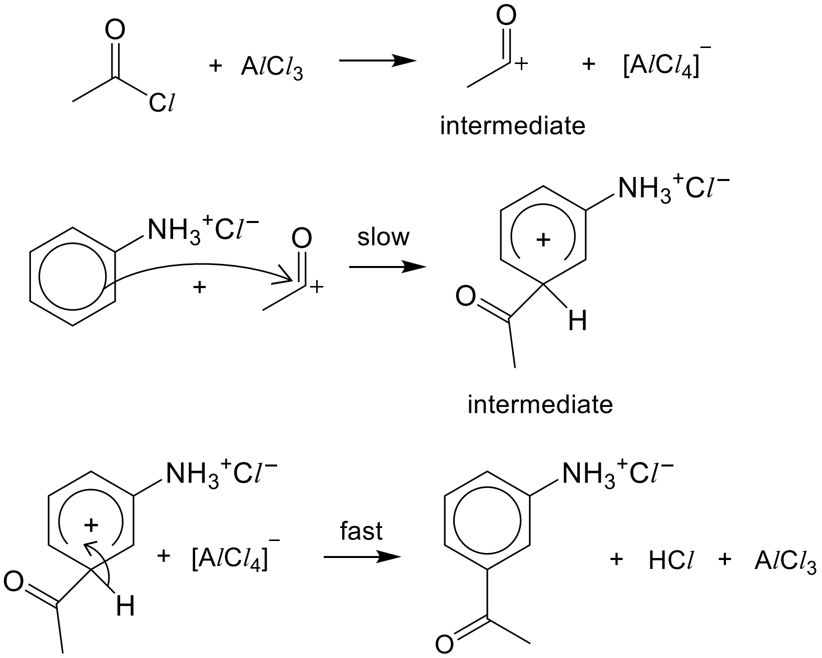
Q23 (Ans: B)



Statement 1 is incorrect as the compound contains a methyl substituent which has a tetrahedral geometry with respect to the $-CH_3$ carbon.
Statement 2 is correct as the compound contains one chiral carbon labelled (*).
Statement 3 is incorrect as the compound is a cyclic alkene which does not exist as cis-trans isomers. The trans-isomer does not exist due to ring strain.

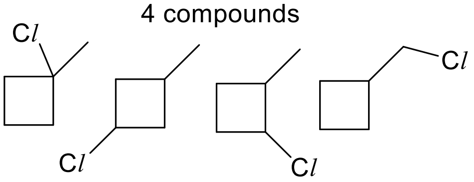
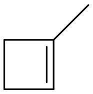
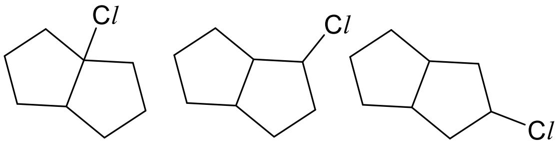
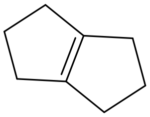
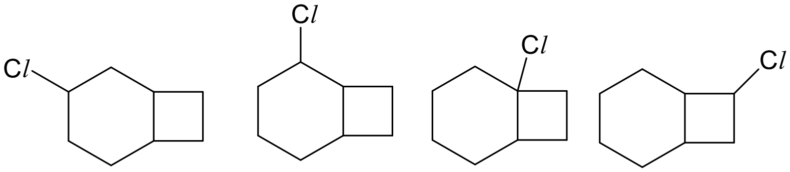
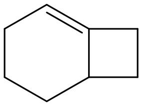
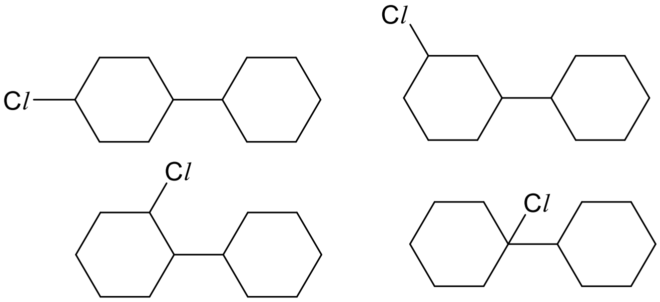
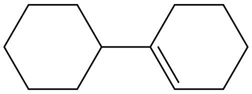
Q24 (Ans: C)

Note that, from the *Data Booklet*, $-NH_3^+$ is a 3−directing group.



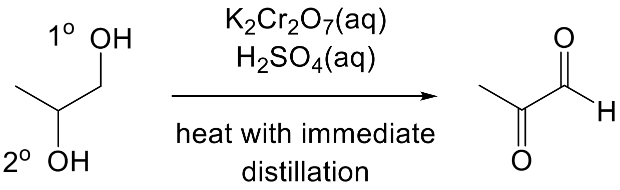
Q25 (Ans: C)

For elimination reactions of alcohols or halogenoalkanes to form alkenes, the major product is the alkene with the greater number of alkyl groups attached to the doubly bonded carbon atoms i.e. the more substituted alkene.

	No. of monochlorinated compounds	Major product
1	Correct 4 compounds  	Correct 
2	Incorrect 3 compounds  	Correct 
3	Correct 4 compounds  	Correct 
4	Correct 4 compounds  	Incorrect 

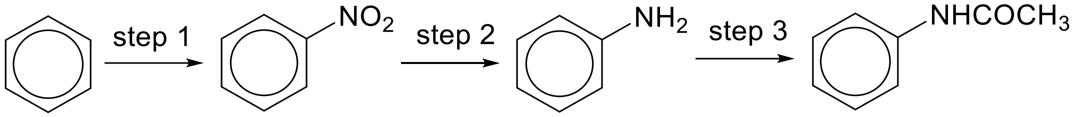
Q26 (Ans: D)

$K_2Cr_2O_7$, H_2SO_4, and heat with distillation will oxidise primary alcohol to aldehyde and oxidise secondary alcohol to ketone.



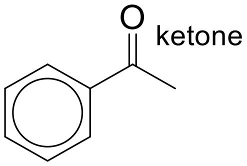
Q27 (Ans: D)

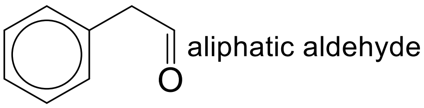
To substitute a nitrogen atom on the benzene ring, nitration via electrophilic substitution is needed, option A is incorrect.
Reduction of nitro group on aromatic ring should be done with Sn with HCl, and not with $LiAlH_4$, option B is incorrect.
Amide formation should be carried using an amine with an acyl halide and not a carboxylic acid. Hence, option C is wrong and option D is correct.



Q28 (Ans: B)

Option 1 is incorrect as 2,4−DNPH will give orange precipitate with both compounds as both have C=O carbonyl groups.
Option 2 is correct as Tollen’s reagent will give silver mirror with the aldehyde, and not the ketone.
Option 3 is correct as Fehling’s reagent will give brick-red precipitate with the aliphatic aldehyde, and not the ketone.
Option 4 is incorrect as purple $KMnO_4$ will be decolourised with both compounds as side-chain oxidation will take place for both compounds.

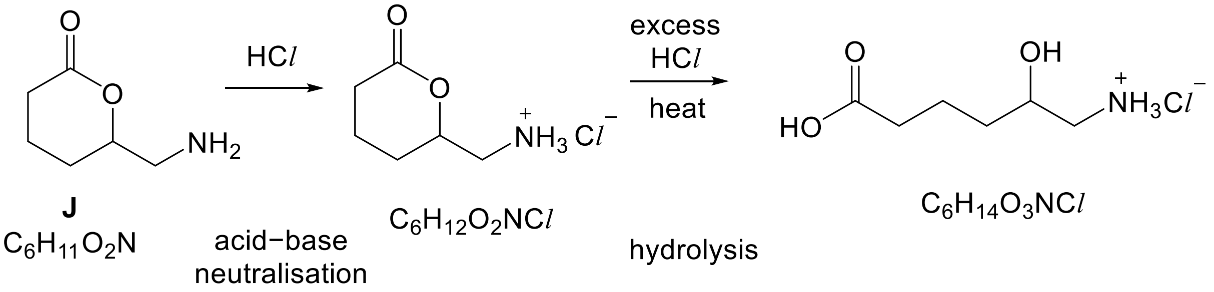




Q29 (Ans: C)

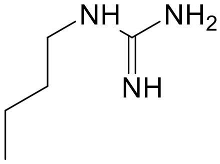
Reaction of **J,** $C_6H_{11}O_2N$ with HCl (without heating) is an acid-base neutralization reaction to give salt $C_6H_{12}O_2NCl$ (increase in 1 H and 1 Cl). Compound **J** is basic and contains the amine $-NH_2$ group as in option **C**. (Option A contains neutral −CN group, while options B and D contain neutral amide groups).

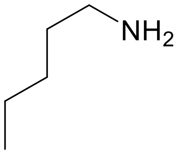
Heating the mixture containing the salt $C_6H_{12}O_2NCl$ and HCl results in hydrolysis to give $C_6H_{14}O_3NCl$ (increase in 2 H and 1 O). Since no atoms were lost in the hydrolysis reaction, this suggests that the functional group that was hydrolysed is part of a ring structure.



Q30 (Ans: A)

Amide side chains are not basic and will not be protonated.

The 

and 

are basic and will be protonated.

Hence, the peptide in option **A** is cleaved as shown to give 3 different products.